KING COUNTY CONVEYANCE SYSTEM IMPROVEMENT PROJECT

PACIFIC PUMP STATION

TASK 310 REPORT

DRAFT

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KING COUNTY
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EXECUTIVE SUMMARY

The King County Conveyance System Improvement (CSI) Project involves planning efforts for on an array of wastewater pump station and conveyance system improvements. The purpose of this study is to evaluate the existing Pacific Pump Station and related conveyance system components, and identify improvements needed to convey the projected increasing basin flows.

The Pacific Pump Station is located on Tacoma Boulevard North in a residential area of the City of Pacific. The station serves approximately 1,500 acres in the cities of Pacific and Algona. Flows are conveyed via a 2,940-foot force main to upstream manhole RE*ALPAC 238 of the Auburn/West Valley Interceptor.

The most recent flow projections, prepared by King County in July 1999, indicate that the 1996 pump station base flow of 0.35 million gallons per day (mgd) is projected to more than double to 0.74 mgd in 2050 as the service area is further developed. In addition, the infiltration and inflow (I/I) flows are projected to increase as a result of growth in the service area and deterioration of the collection system. The estimated I/I (year 2030) in the Pacific Pump Station service area is 5,931 gallons per acre-day for the 20-year peak storm.

Under existing flow conditions, the Pacific Pump Station has a number of operational problems that will continue to be exacerbated as flows increase. In addition, operation and maintenance personnel have raised several issues regarding the accessibility and safety of the pump station. Based on the severity of the potential problems, and the evaluations of the existing system detailed in this report, the following recommendations were developed:

- The pumps are of insufficient capacity to convey the existing and future peak service flows projected by King County and therefore must be replaced with larger equipment. The switch gear, motor control center (MCC), and associated electrical equipment must be replaced to accommodate larger pump motors.

- The existing pump station is located in the City of Pacific street right-of-way. The size and servicing requirements for a new pump station will likely require purchase of property comparable to a residential lot.

- The pump station consists of a fabricated steel dry well unit and a precast concrete wet well. Access to the dry well portion is provided by a 3-foot diameter, 20-foot deep access shaft. The dry well is approximately 8 feet in diameter with no space for additional or larger pump inlets. Clogging of the pumps by rags has been a frequent problem that requires removal of the motor unit to access the impeller. The spatial limitations inside the dry well make these operations extremely difficult and unsafe. The dry well should be enlarged to accommodate larger pumps and equipment, and it should provide a safer and more accessible space to access that equipment.

- The wet well is a confined space that requires special procedures and equipment for entry. Access into the wet well is difficult and dangerous, which generally discourages the required periodic maintenance. As a result, the wet well is a source of odors and corrosion that will become more significant as flow and service loading increase. The existing wet well should be replaced with a safer and more accessible wet well.

- The existing 12-inch force main cannot carry future flows projected by King County without unreasonably high velocities and pumping heads. To increase the force main capacity to carry higher pumping rates, either a parallel force main should be added or the existing force main should be replaced with a larger-diameter pipe.

- The pump station has no dedicated backup power supply. King County must transport a portable generator to the station during power outages to provide emergency backup power. To improve reliability, a permanent generator facility should be constructed at this station as part of any future upgrade.

- There is no emergency overflow control at this facility. Flows exceeding the pumping capacity of the station and power outages have caused backups and overflows into residences in the surrounding service area. Improved reliability will reduce the likelihood of overflows, however overflow control should be evaluated during design of the improvements.

- The current station monitoring instrumentation is Microtel 500. This system has not been reliable and should be replaced. The system often goes into halt mode when spikes or interruptions occur and must be reactivated through a local manual reset at the station. This problem is being corrected as part of the Lakeland Hills Pump Station replacement project.

- The existing pump wastewater seal-flushing water supply should be replaced with a clean, protected water supply. Pressurized water for washdown is also needed at the site. Water for operations should be provided at the facility.

Due to the potential for flow to exceed capacity at the present time, the improvements identified above are recommended even if an inflow/infiltration (I/I) reduction program could offset the projected increase in flow. However, I/I reduction may have merit over the long term for both local systems and the larger King County conveyance and treatment systems.

For purposes of this planning study, a facility replacement was developed based on the design of recent King County pump station. In order to develop sufficient scale and scope of a replacement pump station, specific manufactured pumps were identified. These products are identified in the report but it should be noted that final selection of equipment for bid specifications must be done during final design.

This “typical” King County pump station includes non-clog centrifugal pumps in a dry-pit with separate wetwell. The pumps are electric motor driven at variable speed. The station is ventilated to conform to fire code classifications. Passive carbon-bed odor control, equipment lifting and diesel engine-driven standby power generation systems are included. The typical or conventional facility is compared to alternatives defined around alternative pumping equipment including solids-handling column pumps and submersible pumps and a “packaged” station.

The total project costs for the several alternative pump stations at the present location ranges from $3.9 million to $4.6 million including a parallel force main. Property acquisition costs have not been identified. There is some potential for relocating the pump station north along the route of the force main although gravity conveyance must be constructed to deliver flow to a station located at alternative sites. Two alternative sites were evaluated to assess the cost impact of relocation. At these sites, proceeding north, an additional cost of $675,000 and $1.9 million will be incurred by the project.

CHAPTER 1 – INTRODUCTION

The purposes of this report are to evaluate the existing Pacific Pump Station and related wastewater conveyance system components, and identify the improvements necessary to convey the projected flows from this service area over the next 20 to 30 years.

PUMP STATION HISTORY

King County's Pacific Pump Station is located on Tacoma Boulevard North in a residential area of the City of Pacific. The Pacific Pump Station discharges through a 12" force main to the County's West Valley Interceptor at manhole RE*ALPAC 238. The County system is shown in Figure 1-1. The Sleavin-Kors Engineers originally designed the station for the City of Pacific in 1969. Construction of the pump station and force main was completed in 1971 (Table 1-1). There have been some minor modifications to the pump station since it was completed, including addition of a jib crane slot for assisting in equipment removal and replacement, installation of a portable generator connection for system operation during power outages, and installation of an above ground electrical control cabinet. King County assumed some operation and maintenance responsibilities of the station in 1990 and has since gradually assumed all operational responsibilities from the City of Pacific.

Table 1-1. Pacific Pump Station Construction/Upgrade Information

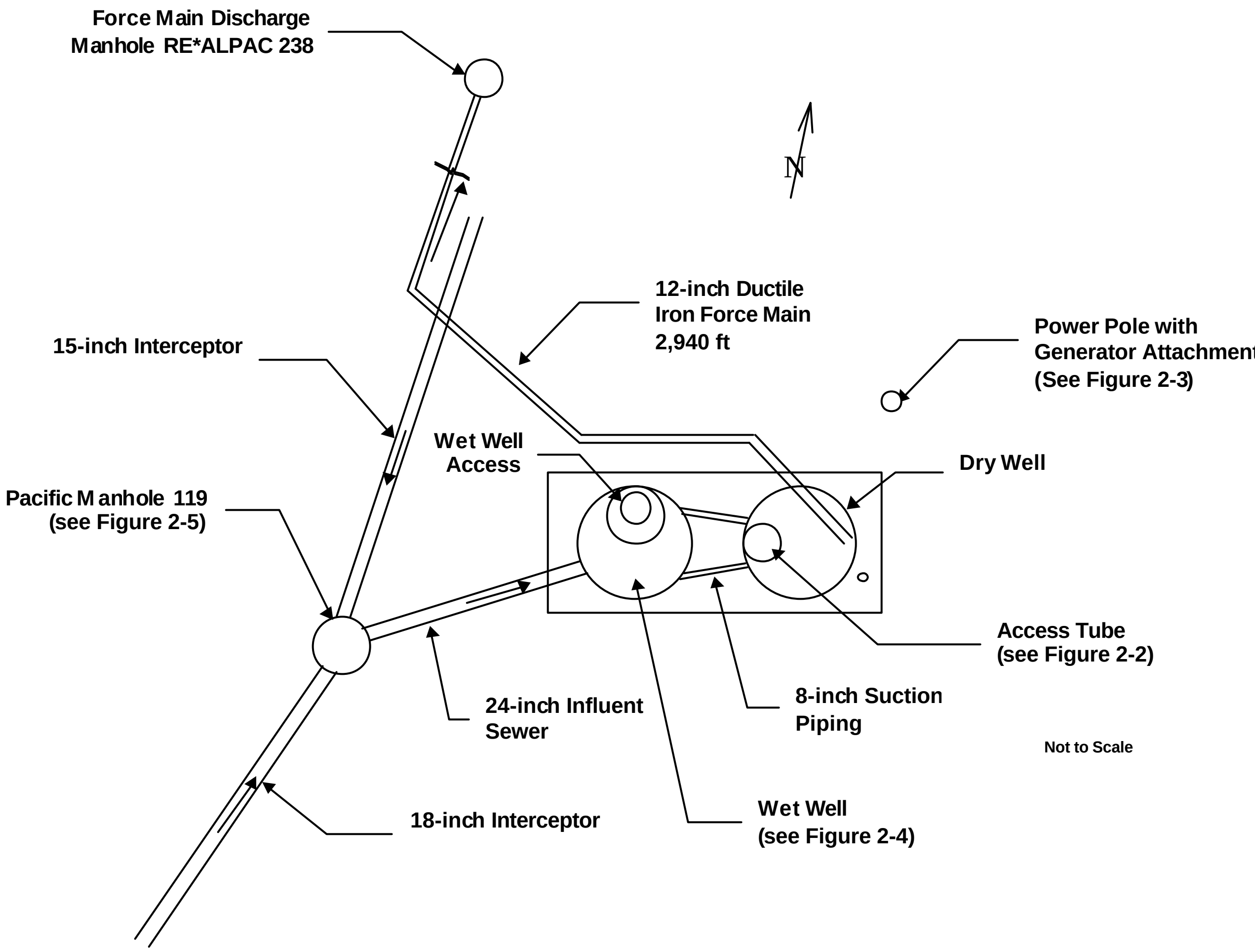
Construction/Modification	Date Completed
Construction of Pacific Pump Station and 12-inch force main	1971
Replaced Pump 1 Impeller	1991
Replaced Pump 2 Impeller	1997
Installed portable emergency generator connection, jib crane slot, and above grade control panel	1998

SERVICE AREA AND COLLECTION SYSTEM RELATIONSHIPS

The Pacific Pump Station serves approximately 2,117 acres in the cities of Algona and Pacific, of which 1,436 acres are currently sewered. The areas of service are primarily residential, with some industrial and commercial customers. The main interceptors to the pump station are 18-inch diameter and 15-inch diameter gravity sewers. These serve the areas north and south of the pump station. Flows from these gravity sewers converge in a manhole next to the pump station and enter the wet well through a 24-inch pipe. Two pumps discharge unscreened, raw sewage from the wet well into a single 12-inch force main. This force main extends 2,940 feet from the pump station to the Algona Pacific Interceptor at manhole RE*ALPAC 238, a total lift of approximately 15 feet. This line eventually flows into the Auburn/West Valley Interceptor, which in turn conveys wastewater to the East Section Reclamation Plant in Renton as part of the South Interceptor collection system. A schematic diagram of the pump station system is shown in Figure 1-2.

Figure 1-1. King County Conveyance System in the City of Pacific

Figure 1-2. Pacific Pump Station Existing Layout



OPERATION AND MAINTENANCE REQUIREMENTS

The Pacific Pump Station is part of the East Section Offsite Facilities. King County operation and maintenance (O&M) personnel visit this pump station every two days for inspection, monitoring, and maintenance.

FUTURE FLOW PROJECTIONS

The most recent flow projections prepared by King County in July 1999 indicate that the 1996 pump station service area base flow of 0.35 million gallons per day (mgd) will increase to 0.62 mgd by year 2030. The flow will further increase to 0.74 mgd by year 2050 as the basin is further developed (Table 1-2). The design life of pump station equipment is typically 20 to 30 years. Any replacement equipment should be sized to accommodate the year 2030 flows listed in Table 1-2, although the basic pump station structure should be sized to accommodate equipment sized for the year 2050 flows.

Table 1-2. King County Flow Projections for Pacific Pump Station

Year	Base Flow (mgd)	5-yr Storm I/I Flow (mgd)	5-yr Storm Peak Flow (mgd)	20-yr Storm I/I Flow (mgd)	20-yr Storm Peak Flow (mgd)
Existing Capacity: 3.0 to 3.2 mgd					
1996	0.35	2.81	3.16	3.44	3.79
2000	0.38	3.12	3.50	3.82	4.20
2010	0.47	3.94	4.41	4.82	5.29
2020	0.56	4.84	5.41	5.92	6.49
2030	0.62	5.13	5.75	6.28	6.90
2040	0.68	5.13	5.81	6.28	6.95
2050	0.74	5.13	5.87	6.28	7.02

Notes:
1. Flow information provided by King County.

POTENTIAL FOR INFILTRATION AND INFLOW REDUCTION

The infiltration and inflow (I/I) flows are projected to increase, to account for deterioration of the existing collection system and construction of new sewers in expanding service area. The 20-year peak flows include a 7 percent increase in I/I rates per decade, resulting in an 85 percent total increase over the 1996 condition by the year 2050. As a result of these projected I/I and base flow increases, the peak 20-year flow is projected to increase to 6.90 mgd by 2030, well above the 3.4 mgd calculated nominal peak capacity of the existing pump station. Table 1-3 illustrates I/I flow projections.

King County is currently developing an I/I control program to reduce flows and thereby reduce operational costs as well as save capital costs associated with building additional conveyance and treatment facilities. The 2030 predicted I/I in the Pacific Pump Station service area is 5,931 gallons per acre-day for the 20-year peak storm. This I/I flow is slightly higher than other similarly sized basins in south King County, based on the County's current projections.

If the I/I control program can offset the effect of deterioration of the service area collection system, which is composed primarily of smaller local sewers, the peak flow projections could be revised downward. For example, if the I/I program can offset the effects of system deterioration to maintain year 2000 I/I levels, the peak 20-year storm flow in 2030 would be reduced from the originally projected peak flow of 6.90 mgd to 4.44 mgd (Table 1-3). If a more aggressive I/I program is implemented and a 5 percent reduction in I/I can be achieved in succeeding decades, the peak 20-year flow could be reduced further to 3.90 mgd by 2030.

Table 1-3. Flow Projections with Infiltration and Inflow Reduction

Year	No I/I Control		Fixed[1]		Reduced[2]	
	Base Flow (mgd)	20 yr. Peak (mgd)	20-yr I/I (mgd)	20-yr Peak (mgd)	20-yr I/I (mgd)	20-yr Peak (mgd)
1996	0.35	3.79	3.82	4.17	3.44	3.79
2000	0.38	4.20	3.82	4.20	3.82	4.20
2010	0.47	5.29	3.82	4.29	3.63	4.10
2020	0.56	6.49	3.82	4.38	3.45	4.01
2030	0.62	6.90	3.82	4.44	3.28	3.90
2040	0.68	6.95	3.82	4.50	3.11	3.79
2050	0.74	7.02	3.82	4.56	2.96	3.70

Notes:
2. I/I rate fixed at year 2000 levels. 20-yr. peak calculated by adding base flow to fixed I/I flow.
3. I/I rate reduced by five percent from previous decade starting in year 2000. Peak flow calculated by adding base flow to resulting reduced I/I flow.
4. Flow information provided by King County.

Improvements and upgrades at the Pacific Pump Station are required to provide capacity to convey flows that can occur at the present time. An extended and substantial I/I reduction effort could reduce the long-term projected flow, although the extent and cost of that effort cannot be estimated from currently available information. Since the projected flow increase is greatest during the next 10 to 20 years, it is unlikely that sufficient I/I reduction can be achieved soon enough to consider a significantly lower station design capacity. However, a capacity of 5.5 to 6.0 mgd would provide adequate service for the next 10 to 15 years, during which time an I/I reduction program could be implemented to limit future I/I increases. Project requirements for 6 mgd capacity versus 7 mgd would be a matter of equipment sizing. Project scope would be similar in either case.

Because the success of an I/I reduction program is not known at this time, the proposed pump station structure and its related components such as standby power, odor control and electrical service should be sized to accommodate the year 2050 20-year peak flow without the predicted I/I reductions.

CHAPTER 2 – EXISTING PACIFIC PUMP STATION

The Pacific Pump Station is located in a residential neighborhood on the undeveloped right-of-way for First Avenue NW in the City of Pacific.

The general description and evaluation of the pump station is based on record drawings found in King County archives. Elevation references were not associated with a specific datum, however the elevations notes on those drawings appear consistent with the Mean Sea Level (MSL) datum. Our evaluation assumes a MSL datum to which we have added 100 feet for conversion to "Metro" datum for correlation to other King County system components.

The pump station consists of a separate wet well and below-grade dry well (Figures 2-1 through 2-5). The dry well is a packaged unit manufactured by Smith and Loveless of Lenexa, Kansas and consists of an 8-foot diameter by 9-foot high metal canister, a 3-foot diameter metal access tube, and security hatch. The wet well is a 10-foot diameter precast concrete manhole modified into a wet well. The dry well floor elevation is approximately 23 feet below grade, thus requiring a 14-foot deep access tube. The motor control center (MCC) and panel controls are located in the dry well space along with two centrifugal pumps. Ventilation is provided continuously by a small ventilation unit located in the dry well. A small air compressor for the level measuring bubbler is also located in the dry well.

The wet well is located approximately 10 feet west of the dry well. A 24-inch influent pipe enters the wet well from the southwest. This pipe connects to a manhole that collects flows from two separate interceptors. Two 8-inch suction pipes connect the pumps individually to the wet well. A metal grating partially extends over the wet well, as shown in Figure 2-4.

King County has made several improvements to the original facility. O&M personnel have modified the station to provide for the use of a jib crane to facilitate equipment removal and have attached a connection to an adjacent power pole for a portable generator. Electrical controls and meters were also routed to a surface electrical cabinet to reduce the need for routine entries into the dry well.

EXISTING STATION PUMP AND FORCE MAIN CAPACITY

The existing sewage pumping system includes two constant-speed pumps (Table 2-1). The system operates in an on/off mode, alternating pumps into service at each cycle. The pumps typically operate at wastewater elevations in the wet well between 6.0 and 12.0 feet above the bottom of the wet well.

The capacity of the existing pumps was evaluated by assuming a range of hydraulic conditions in the existing force main and station piping. Pacific's two pumps discharge into a common 12-inch diameter ductile iron (DI) force main. The force main, along with the fittings, valves, and pipe sections inside the pump station, was used to develop a system capacity curve. Pump curves for the existing pumps (provided by Smith and Loveless, the existing pump manufacturer) were compared to the calculated system curves for various operational conditions, expressed as various Hazen–Williams C values (Figure 2-6).

Table 2-1. Pump Station Capacities

Pumps		No. 1 and No. 2	
Model		Smith & Loveless 6C3	
Type		Non-Clog Centrifugal	
Rating	Flow (mgd)		
	C_{HW}=100	C_{HW}=120	C_{HW}=140
Firm	2.0	2.1	2.2
Maximum	2.7	2.9	3.2
Pump Speed		1170 RPM	
Motor Horsepower		15 HP	

Figure 2-1. Pacific Pump Station Section

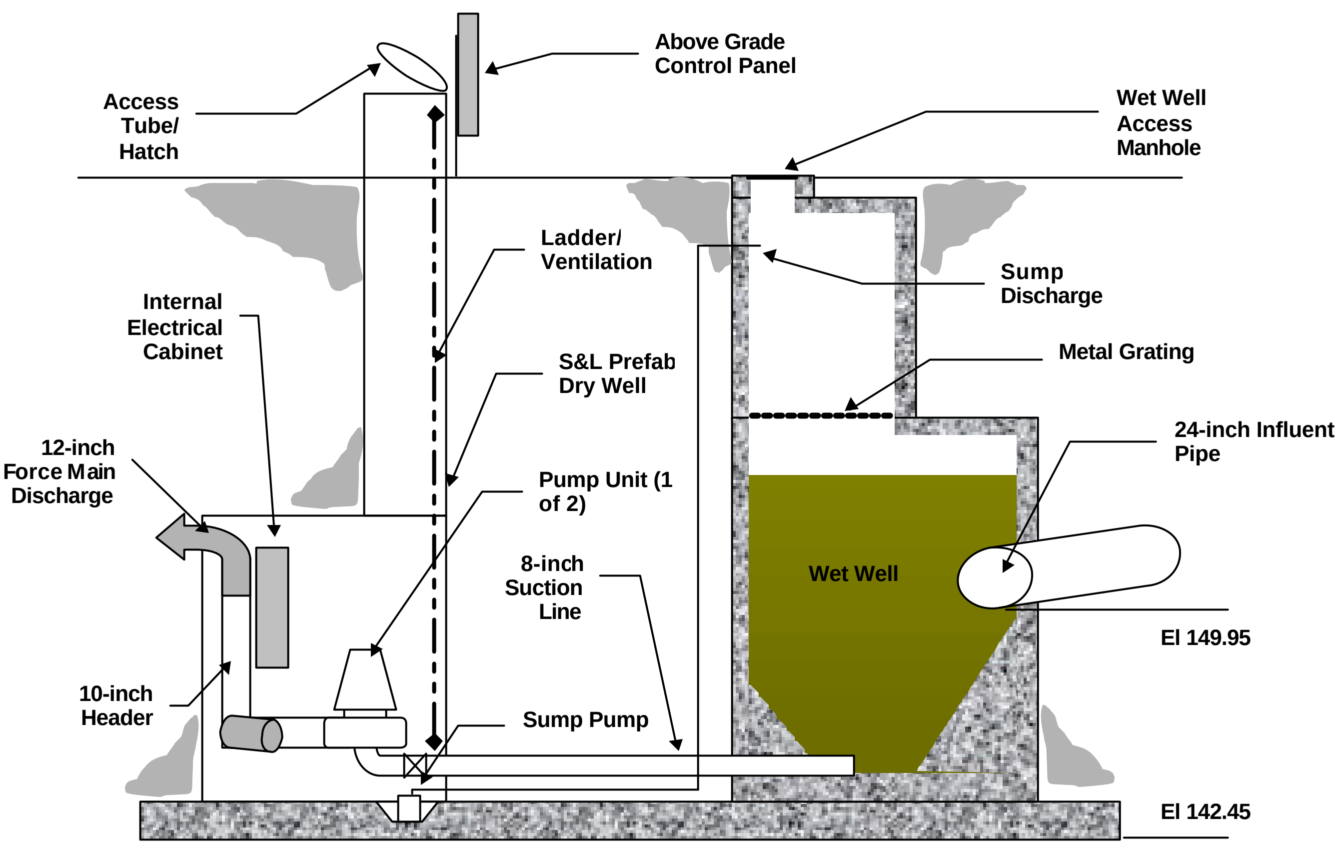


Figure 2-2. Dry Well Access Tube

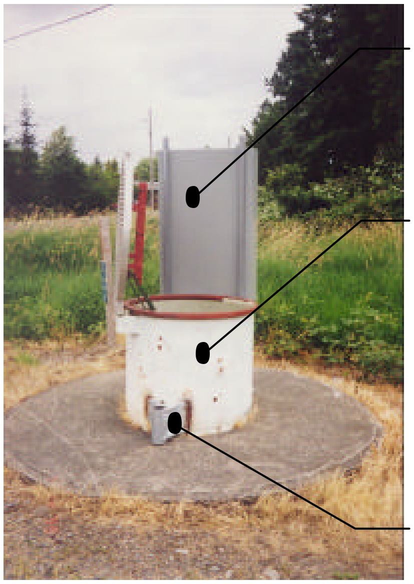


Figure 2-3. Emergency Generator Connection

Figure 2-4. Wet Well

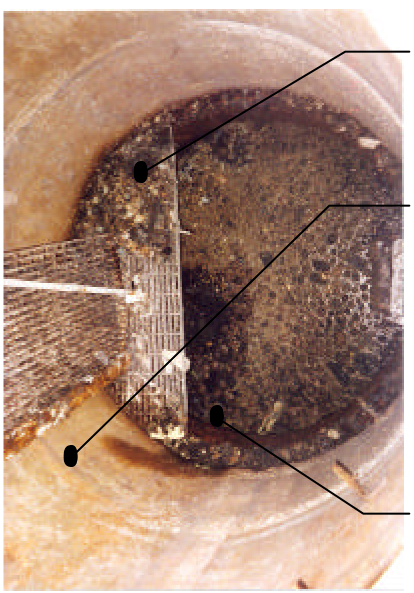


Figure 2-5. Influent Manhole

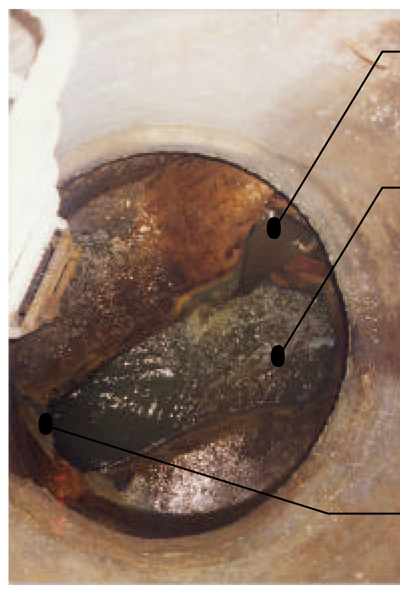
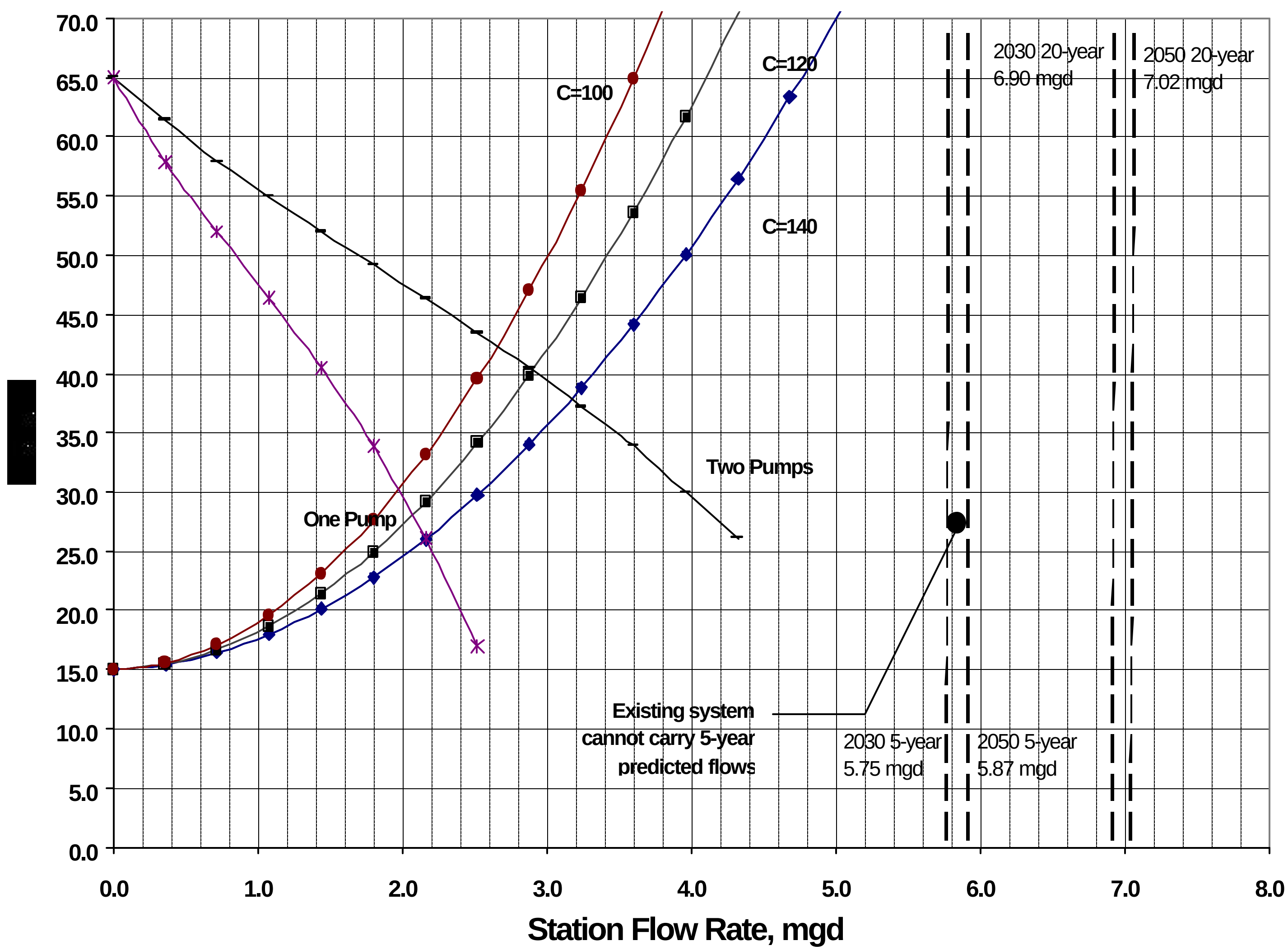


Figure 2-6
Pacific Pump Station
12-inch Force Main with Existing Pumps at Varying C Values



King County defines firm and maximum pumping capacity requirements based on service conditions under design rainfall events. The firm capacity is the flow rate of the 5-year peak storm, which must be conveyed with one pump unit out of service. The maximum (peak) flow rate is that of the 20-year peak storm event. A station must be able to convey this flow using all available pumping units. Following this criteria, the firm capacity of the existing Pacific Pump Station would be based on the pumping rate with one pump out of service, and the maximum capacity would be based on all units in operation.

Using the system relationships illustrated in Figure 2-6 and existing record drawings for the pump station and the force main, the pumping rates of the existing pump units were estimated at varying Hazen–Williams coefficients of 100, 120, and 140.

Based on this estimation, the capacity of the existing pump station is inadequate to convey either the current 5-year or 20-year storm flow (see Table 1-2). The pumps must be replaced in order to meet the current and projected firm and maximum capacity requirements.

PUMP CONTROLS

The existing pumps are started and stopped based on measured water levels in the wet well. A bubbler is used to measure liquid level in the wet well. At a predetermined water level, the lead pump will activate and operate at constant speed until the water level recedes to the preset, lower stop level. If the water level continues to rise, the second pump, or lag pump, will be activated and operated with the lead pump until the water level recedes.

STATION PIPING

In addition to the pumps, the station piping was evaluated for hydraulic performance under existing and projected flows. Because the pump station is so compact, the station piping consists of 8-inch diameter valves and pipe fittings. There is little if any pipe spool used in the existing station piping. A 6-foot section of 10-inch diameter steel pipe acts as a common header and is located just before the force main exits the dry well, at which point the diameter increases to 12 inches. Suction piping is shown on record drawings as 8-inch diameter ductile iron. Each pump is equipped with a check valve and an isolation valve on either side of the pump unit.

Velocities in the suction and discharge piping were evaluated for a range of flows, including current and future firm and maximum flows, and compared to recommended standard design velocity criteria (Sanks et al., *Pump Station Design*). The recommended maximum velocity in suction piping is 5.0 feet per second (fps), and the recommended maximum velocity in discharge piping is 8 fps. At the existing firm capacity (with one pump in operation), the suction velocity in the 8-inch piping is 8.4 fps, exceeding the recommended maximum. The discharge velocity in the 8-inch fittings and valves is also exceeded. The velocity in the 10-inch header at the existing station's maximum pumping capacity (with both pumps in operation) is 8.0 fps, the recommended maximum. Based on these comparisons, the existing suction and discharge piping is near the upper range of recommended velocities for projected design flows with the existing pumps. Larger pumps designed to carry a larger flow rate would exceed the velocity limits in the suction piping and discharge piping.

Because the existing station piping and fittings cannot carry the projected firm and maximum capacities, and are near the end of their 30-year design life, together with the probability that newer, larger pumps will have larger-diameter connections and greater hydraulic capacities, the existing station piping and fittings should not be reused.

WET WELL DESCRIPTION AND HYDRAULICS

The existing wet well is a 23-foot deep concrete manhole. The lower portion of the manhole is a 10-foot diameter section that is approximately 10 feet deep. The upper section is reduced to a 7-foot diameter section that extends to ground surface. The bottom wet well is shown on record drawings as having filets at the bottom to direct solids toward the pump intakes. The calculated usable volume of the wet well (before backups into the contributing interceptors occur) is approximately 5,000 gallons.

The wet well has metal grating at the bottom of the 7-foot diameter section. The original grating in the wet well extended across the entire area. County personnel have partially removed the grating to reduce debris accumulation due to lack of water available at the site for periodic washing down of the wet well (see Figure 2-4). However, because of the inaccessibility of the wet well and its associated safety concerns, maintenance activities are limited. Access is provided by manhole rungs in the side of the wet well. Workers use a tripod and harness retrieval system for entering the wet well.

Wastewater enters the wet well through a 24-inch pipe that is submerged. Although the pipe is exposed during drawdown, minimal cascading occurs during the cycle, thereby preventing significant air entrainment and odorous gas generation.[1]

The operating volume of the wet well is the volume between the pump start and stop levels. The maximum volume available for pump operation occurs between the level providing required pump intake submergence and the influent sewer crown elevation. To avoid overheating, pump motors should not be started more than six times per hour. For a given wet well volume, pump cycle time is minimized when the influent flow rate is one-half of the pumping rate. Based on the calculated operating volume of the existing wet well and the estimated pumping rate, the minimum pumping cycle is about 13 minutes. Since the pumps are automatically alternated into lead position, actual minimum motor starting cycle time is 26 minutes, or about two starts per hour.

Presently, in the event of a mechanical or power failure to the pump station, wastewater at average daily flows can be stored in the wet well and influent sewer for less than 20 minutes before overflowing. The existing wet well was not constructed with a designated overflow relief system. Backups into local residences and businesses can occur as water levels rise in the wet well when flow exceeds pump capacity or system failure interrupts pump operation.

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[1] Confirmed during field inspection, July 13, 1999, by Herrera Environmental Consultants.

CONTROL SYSTEM

The fully automatic pump station is normally unattended and is controlled from panels in the dry well. Staff at the East Section Reclamation Plant in Renton monitor the operations of the pump station through the Microtel 500 SCADA system. This system is outdated by current King County standards. Operators have reported that the system is not reliable and often goes into halt mode when power surges occur, requiring a manual reset at the site and typically resulting in backups to nearby residences and businesses. Because the existing SCADA system functions poorly, the County has currently scheduled replacement with a new Modicon unit as part of another project (Lakeland Hills Pump Station Upgrade).

The pumps are controlled from the wastewater level in the wet well, which is measured by a bubbler. The wet well lacks a redundant system with an additional bubbler or float switches to turn on the pumps in case the primary bubbler system fails. There is no flow meter located at this facility.

AIR SYSTEM

The existing air system provides instrument air for the wet well bubbler system. The system consists of duplex air compressors, receiver, and ancillary equipment. This system was recently replaced and has worked reliably since then.

ELECTRICAL POWER SYSTEM

Power is supplied to the pump station by the local energy utility (Puget Sound Energy). In the event power is lost, there is no backup or alternative power supply. King County is required to transport a portable generator to the site and connect to the fitting shown in Figure 2-3. This portable generator has the capacity to operate the existing pumps for 24 hours. In general, outages to the existing pump station are rare. The existing electrical utility services the pump station from a single substation. There are no other substations in the area available for a secondary power feed. The existing switch gear and motor control centers (MCCs) were installed during the original construction. This equipment is old and reportedly in need of replacement.

WATER SYSTEM

There is no existing water supply (potable C1 or nonpotable C2) at this facility. These systems are required to facilitate scheduled wet well washdown and station cleanup.

The pumps operate using a seal water system to flush, lubricate, and cool mechanical shaft seals. At the Pacific Pump Station, seal water is supplied from the pump and is filtered. Field observations suggest that maintenance of the filters on these systems is infrequent and could result in reduced seal water flow and subsequent seal damage.

DRY WELL DRAINAGE SYSTEM

The dry well drainage system consists of a small sump and float-controlled sump pump located in the dry well at the landing of the access tube ladder. This feature is part of the prefabricated dry well structure. The drainage system collects spillage and discharges through a 1-inch diameter line to the wet well. This system was recently repaired by King County and is functioning properly. The capacity of this pump is estimated at 20 gallons per minute (gpm). The system assists in draining any spillage from maintenance but would not protect the motors or electrical controls in the event of a major leak or rupture.

HVAC SYSTEM

The existing ventilation system consists of a small fan unit that operates continuously to supply fresh air to the dry well. The flow rate of this unit has not been determined. Heating is not provided by the existing ventilation system.

National Fire Protection Association (NFPA) code 820 requires that the dry well and other parts of the pump station that are not exposed to sewer gases be ventilated continuously at six air changes per hour (ACH). In addition, a system under this regulation should be designed to maintain a net positive pressure in the dry well and connected areas. King County performed an internal audit of the dry well and determined that the existing ventilation system is adequate to meet these requirements.

NFPA 820 further stipulates that the wet well and wet well access be ventilated continuously at 12 ACH. The current wet well does not fall under the NFPA 820 guidance due to its classification as an unoccupied and confined space. Because there is no routine need to access the Pacific Pump Station wet well, King County ventilates the wet well only prior to entry into the confined space and monitors the space for dangerous gases during occupation.

Odor control is currently not provided for the pump station, and there is no history of odor complaints regarding the pump station from the adjacent residential areas. However, the absence of documented odor complaints does not mean that odors are not present.

EQUIPMENT ACCESSIBILITY AND MAINTENANCE CONSIDERATIONS

The design of the dry well does not allow for easy equipment access and maintenance. The primary constraint in accessing the facility is the 3-foot diameter access tube. A slot for a portable jib crane was recently attached to the above-grade portion of the access tube. This crane is used to facilitate moving large objects up the 3-foot diameter access tube. However, this type of operation presents a considerable risk to personnel in the dry well space if the crane fails and materials fall back into the dry well. Minor maintenance operations (particularly clearing the pumps of rags) requires equipment disassembly and there is inadequate floor space to perform this type of work.

Personnel Egress, Safety, and Code Issues

The Uniform Building Code (UBC) defines egress and fire protection requirements for structures. In the Pacific Pump Station, there are separate external entrances for the dry well and wet well. Under current code, a single means of egress is sufficient as long as the occupant load is 10 or less. In addition, the maximum travel distance is 200 feet for unsprinklered buildings such as the pump station. Therefore, with a single means of egress from the dry well and another means of egress from the wet well, the pump station meets the requirements of the UBC.

The wet well is accessible only by manhole rungs. King County personnel enter the wet well using a harness and tripod because of the removed grating and because the wet well is classified as a confined space. Because of the infrequent entries into the wet well, the structure is exempt from UBC and Occupational Safety and Health Administration (OSHA) regulations as an existing structure.

Automatic sprinkler systems are required in certain situations. Because hazardous chemicals currently are not stored in the pump station, and the floors of the pump station are all less than 1,500 square feet, the station is exempt from the requirement for automatic sprinklers.

Pacific Pump Station Force Main

Wastewater is discharged from the Pacific Pump Station into a single 12-inch diameter ductile iron pipe force main, which extends approximately 2,940 feet from the pump station to the discharge point at manhole RE*ALPAC 238 on the Algona Pacific Interceptor. The force main profile is included as Figure 2-7. No information is available on the physical condition of the existing force main. Because there have been no reported problems with sulfide-induced corrosion in this system, the pipe is assumed to be in adequate condition for continued service.

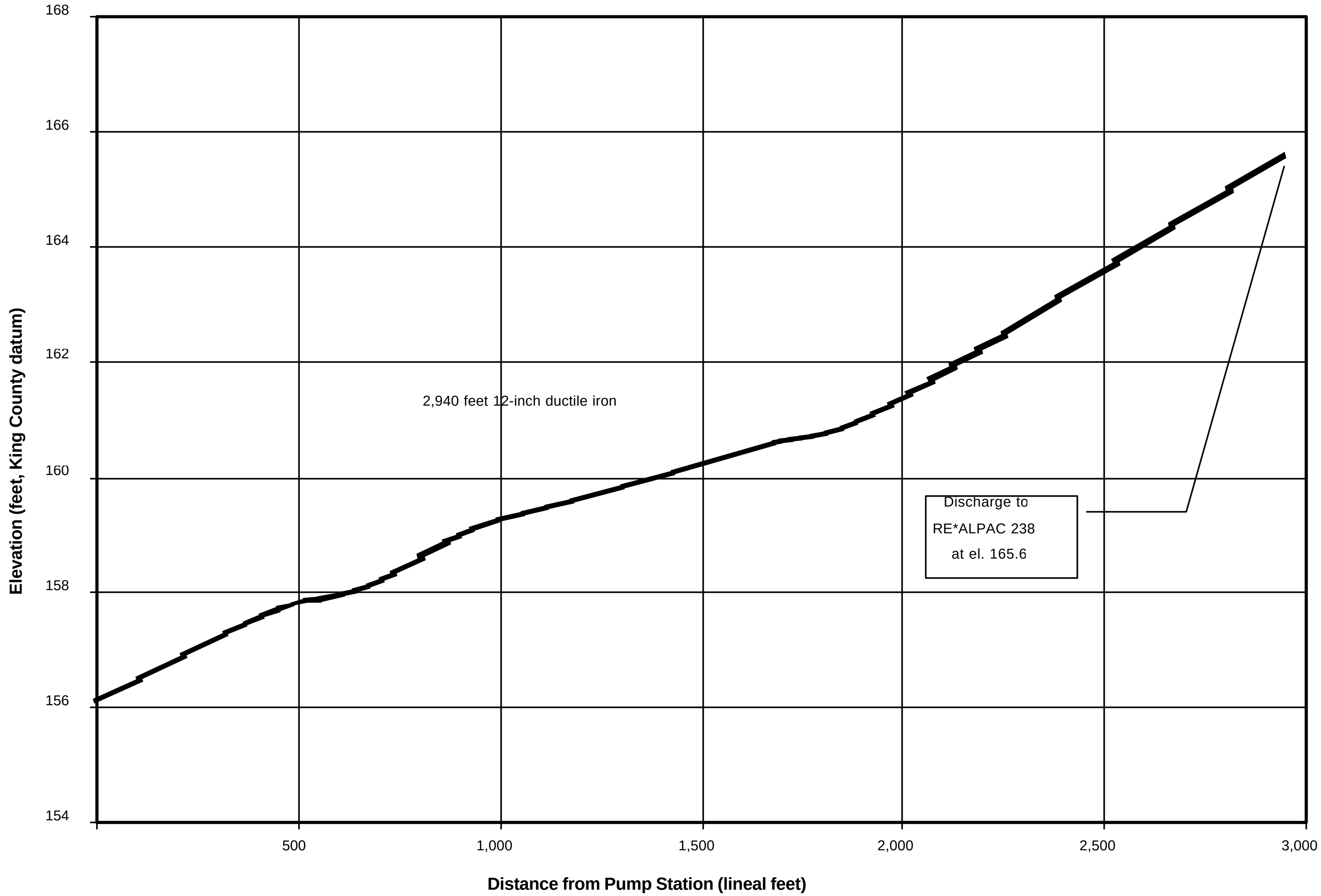
The wastewater velocity is less than 1.0 fps at the measured 1996 base flow and greater than 13.0 fps at projected 2030 peak flows of 6.95 mgd (Table 2-2). The existing force main has a maximum detention time at constant flow of 71 minutes. As a general design consideration, velocities greater than 8.0 fps are considered to result in excessive pipe frictional losses, larger horsepower requirements, and the potential for more severe hydraulic transients. This maximum recommended velocity is exceeded at 4.46 mgd. Projected peak flows will exceed 4.46 mgd by 2010. Therefore, a parallel force main is warranted for hydraulic reasons as well as increased capacity. Parallel force main alternatives are discussed in Chapter 3.

Table 2-2. Force Main Wastewater Velocities

Q (mgd)	V (fps)	Notes
0.35	0.69	ADWF base flows (1996)
2.30	3.56	Estimated firm existing pump station capacity
3.30	7.59	Estimated peak existing pump station capacity
4.46	8.00	Flow at recommended maximum design velocity
5.75	**10.59**	Firm 5-year flow (2030). No I/I control.
6.95	**12.41**	Peak 20-year flow (2030). No I/I control.

Notes:
1. Velocities greater than the recommended value are **highlighted.**

Figure 2-7
Pacific Pump Station Force Main Profile



HYDRAULIC TRANSIENTS

Hydraulic transients have not been reported at the Pacific Pump Station. The existing pumping rates and force main configuration do not suggest that hydraulic transients are likely to be severe, should they occur. The selected alternative should be evaluated in final design to determine if any form of surge control would be required.

INTERCEPTOR SEWERS

Evaluation of the gravity sewers that convey flows from the service areas to this station is based on the original design drawings obtained from the City of Pacific and King County. Service area flows are conveyed through an 18-inch gravity sewer and a 15-inch gravity sewer. Each discharges to a manhole (MH 119) located 25 feet to the west of the wet well (see Figure 2-5). The 18-inch line has a slope of 0.1 percent for approximately 570 feet upstream of MH 119. The 15-inch line has a slope of 0.16 percent for approximately 929 feet upstream of MH 119. Flows are combined at this manhole into a 24-inch concrete pipe that enters the wet well at invert elevation 149.95 (converted to "Metro" datum from assumed MSL datum), which is below the high operational water level in the wet well[2].

Based on the sizes and slopes of these interceptor sewers, the total capacity of the gravity portion of this system is approximately 3.8 mgd (Table 2-3), which is less than the year 2000 20-year storm event flow. The flat slopes may allow sediment accumulation in the bottom of the pipes at lower velocities. The velocity and hence the capacity of the influent sewers could be increased by increasing their grade, which in turn would lower their invert elevation at MH 119.

Table 2-3. Interceptor Sewer Hydraulics

Pipeline Length	Diameter (in)	Slope (ft/ft)	Q_{full} (mgd)	V_{full} (fps)
929	15	0.001	2.15	2.15
570	18	0.0016	1.67	1.67

Notes:
(1) Current peak capacity of the pump station is approximately 3.4 mgd.

These interceptors are part of the conveyance system owned by the City of Pacific, although they serve sufficient area to be considered regional facilities. Regardless of ownership, the pump station operating elevations must accommodate the grades and elevations required for future gravity sewer capacity increases.

[2] During a field visit on July 14, 1999, wet well water levels were observed to fluctuate above and below the crown of the influent pipe during a typical pump drawdown cycle.

EXISTING PUMP STATION EVALUATION SUMMARY

The deficiencies of the Pacific Pump Station are summarized in Table 2-4. Proposed solutions and estimated costs are developed in Chapters 3 and 4.

Table 2-4. Summary of Existing System Deficiencies

System	Comments
Pacific Pump Station	
Raw Sewage Pumps	The pumps are not capable of carrying current-year maximum flows. Impellers have been replaced due to erosion by sediment in wastewater.
Dry Well	The size of the underground dry well limits accessibility to existing pumps and motors. Adding additional or larger pumps to increase capacity is not possible in the available space. Worker safety is jeopardized during equipment removal and replacement. Access to the dry well is difficult and dangerous. The sump pump is too small to control major leaks or ruptures.
Wet Well	The existing wet well shape does not lend itself to addition of another pump intake, and volume available for cycling under projected flows is inadequate. The operating level must be lowered to accommodate future interceptor sewer capacity increase. No emergency bypass or overflow is available. Access is difficult and dangerous and requires confined space entry procedures.
Influent Sewers	The collection system components that connect to the Pacific Pump Station have insufficient capacity to convey future design flows.
Control System	Existing monitoring controls are unreliable and do not meet current King County requirements for these systems. No redundant pump control system is available.
Standby Power	Standby power must be transported to the station after a power outage occurs. No onsite backup power is installed.
Electrical Equipment	Motor control centers (MCCs) and other components are old and are incompatible or undersized for accommodation of additional or larger pumps.
Water	An onsite water supply for maintenance operations is not available.
Personnel Egress and Safety	The access tube to the dry well hinders maintenance of pumps and motors. The dry well has very limited space for working on equipment. The wet well is a confined space that requires special equipment and procedures for entry, hindering required cleaning and maintenance.
Pacific Force Main	
Force Main Capacity	The existing force main cannot carry projected maximum flows. Velocities exceed typical recommended maximum design velocities (8.0 fps) at 4.5 mgd.

CHAPTER 3 – DEVELOPMENT AND EVALUATION OF ALTERNATIVES

King County design requirements stipulate that the firm pumping capacity of the station must convey the 5-year storm flow and the maximum pumping capacity must convey the 20-year storm flow. The existing pumping equipment capacity is substantially less than these projected requirements. Review of available equipment that can convey these flows and be used in raw sewage pumping shows that the existing dry well space is inadequate for installation of the larger pumps, motors, fittings, and piping required. A new facility would be the simplest way to meet the short-term and long-term requirements. The existing pump station could remain in service during construction of a new facility.

The alternatives for a new pump station were developed to meet the following objectives:

- Increased pumping capacity to convey projected flows for the assumed 30-year life of the facility. For this analysis, year 2030 flows are assumed for firm and maximum capacity; however, the difference between 2030 and 2050 flows is small and may fall within the same increment of equipment sizing.
- A basic dry-pit, variable flow pump station, using non-clog centrifugal pumps and conforming to current King County preferences, is developed and compared with alternative stations designed around alternative type of pumps. A “packaged” pump station is also examined.
- Improved reliability for pumping operations by including onsite backup power, backup system controls, and redundant mechanical systems.
- Improved operation and maintenance conditions that address worker safety, better access to equipment, and access to the wet well. A new facility should also reduce man-hour requirements for labor-intensive O&M activities.
- Minimal impact on the surrounding residential community, including odor control, noise abatement, and aesthetic considerations incorporated into the design of the facility.

The existing pump station is located in the existing City of Pacific street right-of-way, which may not provide sufficient space for a new, larger pump station. Alternative sites for locating the pump station have been evaluated.

PUMPING SYSTEM REQUIREMENTS

The existing facility offers little room for the equipment improvements necessary to increase the capacity of the pump station. This limitation, accompanied by the requirement to provide a more accessible and safer facility for King County personnel, mandates replacing the entire facility. Upgrades to the pumping equipment would occur during station construction.

Multiple pumping units would be required to provide adequate service over the full range of present and future flows. The new pumps must convey the peak flow of 7.0 mgd, and 5.8

mgd with one unit out of service. A parallel force main is required to avoid excessive head loss and motor horsepower requirements.

At a peak flow of 7.0 mgd, it is assumed that either two or three pumps would be operating in a new facility, depending on pump type and size. Pump selections are made to provide design capacities concurrently with developing the required piping configuration for the selected pump type. At a minimum, suction piping size must be increased over the existing size to reduce normal and maximum operating velocities. The proposed header arrangement could consist of a single header or dual headers based on pump type.

Larger suction piping required by larger dry pit type centrifugal pumps cannot be accommodated within the horizontal and vertical dimensions of the existing wet well. The wet well must be replaced to accommodate larger suction piping. This can be accomplished by constructing a new wet well as part of the new dry well structure. Further discussion of wet well configuration is presented later in this section.

Several models of pumps capable of producing the required flow rates were identified and evaluated for performance and other installation requirements including motor size. These include dry pit non-clog centrifugal pumps, submersible non-clog centrifugal pumps, and vertical turbine solids handling pumps. Fairbanks Morse manufactures the specific pumps evaluated. They are shown on system curves developed to illustrate single and parallel pump operation with one and two force mains in service. These characteristics represent the specification requirements for pump selection. Other manufacturers should be consulted during design to assure that a pump specification is written to meet design criteria without limiting bidding competition. Specifications should be written to ensure adequate product design and performance for all operating conditions.

The greatest effort was made to identify pumping equipment suitable for operation under all anticipated service conditions. Because of the wide range of flow, other configurations were considered employing different sizes of pumps. Each size was selected specifically to handle only a limited range of the flows. For example, a pump of one size would handle the average daily flows (approx. 0.35 MGD) up to flows in the range of 2-3 MGD. As flows increased, larger pumps would assume pumping duties. However, because of range of flow and head conditions, the small pumps would not contribute to station production during high flow. The result of employing pumps sized for limited flow ranges would be independent pumping systems, each with reliability requirements, a more complex control system and more pumping units.

THREE CENTRIFUGAL PUMPS (DRY PIT TYPE)

Three non-clog centrifugal pumps arranged in parallel were evaluated for meeting the firm and maximum capacity requirements. The pumps evaluated for this arrangement are identified in Table 3-1. The best pump based on the evaluation was selected for this discussion. In Figure 3-1, pump performance is plotted against the existing 12-inch force main system curve and a proposed twin 12-inch force main system curve.

Table 3-1 Pumping Equipment Characteristics (3 Pumps)

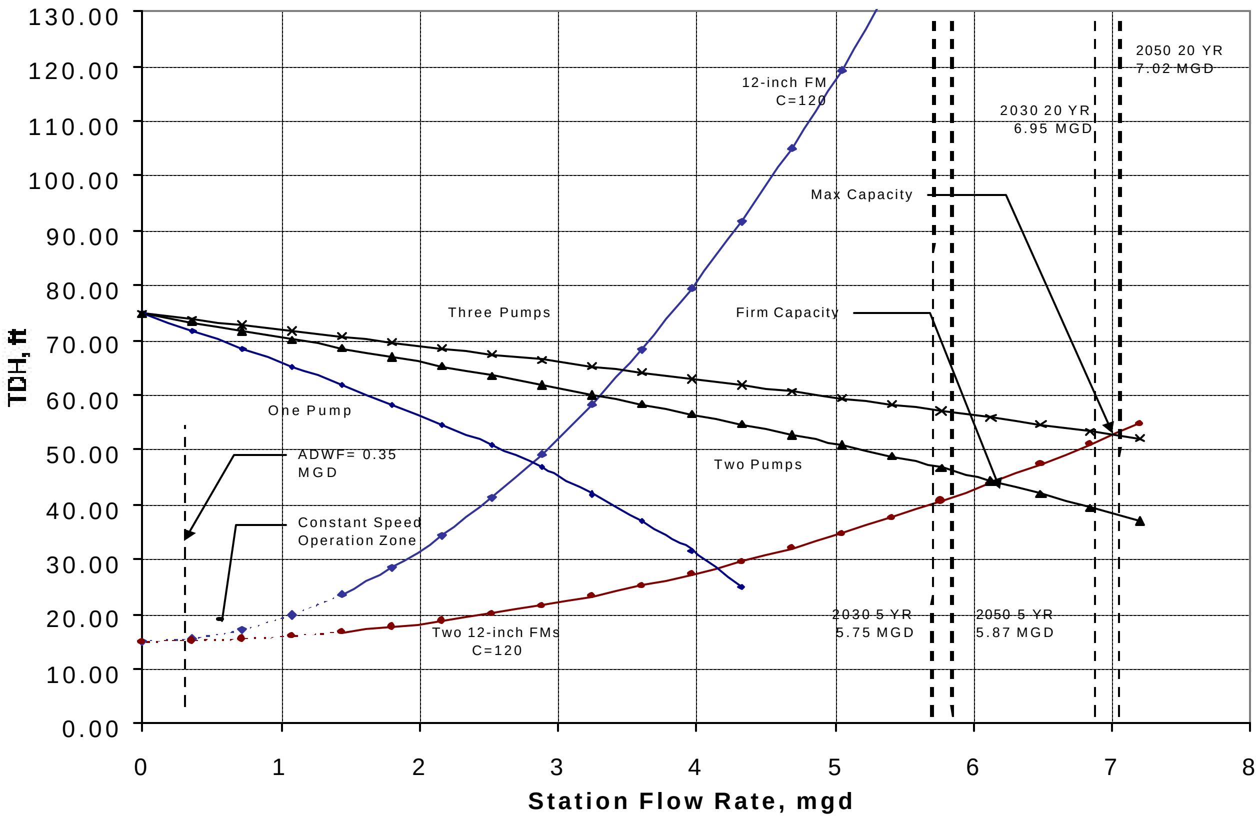
Manufacturer	Model	Suction ø (in.)	Discharge ø (in.)	Max Speed (rpm)	Motor Horsepower Demand (hp)	Min Flow Rate (gpm)	Runout (gpm)	Range of Efficiency (% eff)
Fairbanks Morse	8” 5415	14	14	755	40	900	3,450	52-78
Fairbanks Morse	**8” 5414**	**14**	**14**	**880**	**30**	**700**	**2,850**	**55-79**
Note: Best alternative is shown in boldface type.								

This pumping arrangement uses two pumps to reach the firm pumping capacity of 6.1 mgd, and three pumps to produce the maximum pumping capacity of 7.0 mgd. A single pump can operate down to 700 gpm by using a variable frequency drive. Table 3-2 summarizes system performance.

Table 3-2. Pumping System Performance Characteristics (3 Pumps)

Operating Condition	Single Pump Performance	Suction Velocity (fps)	Brake Horsepower Demand (hp)
Maximum station capacity	1,600 gpm @ 48’ TDH	3.0	26
Firm station capacity	2,150 gpm @ 41’ TDH	4.7	28
Max. runout (C=120)	2,850 gpm @ 26’ TDH	5.4	29
Min. suction velocity (2 fps)	1070 gpm @ 18’ TDH	2.0	7
Min. flow rate @ 1.2 mgd	700 gpm @ 15’ TDH	1.3	6

Figure 3-1
Pump Replacement Option 1
Three Pumps (Dry Pit Type), VFD, C=120



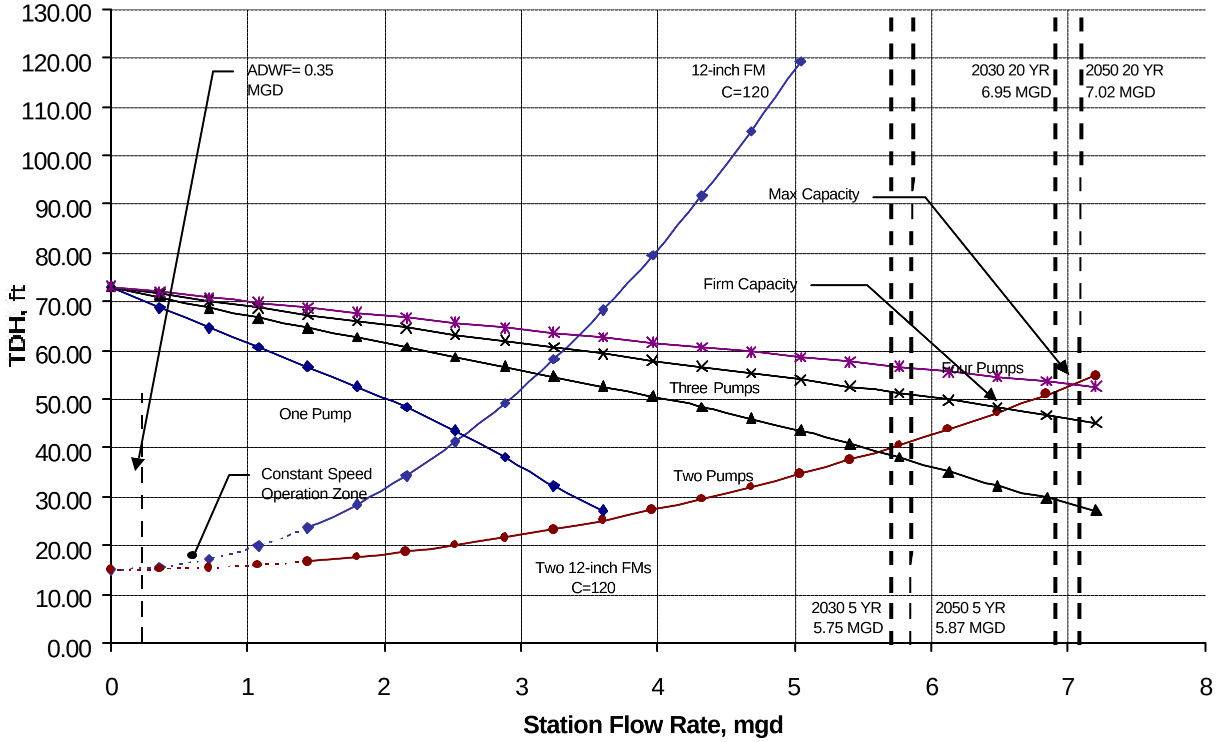
FOUR CENTRIFUGAL PUMPS (DRY PIT TYPE)

Four non-clog centrifugal pumps arranged in parallel were evaluated for meeting the firm and maximum capacity requirements. The pumps evaluated for this arrangement are identified in Table 3-3. In Figure 3-2, pump performance is plotted against the existing 12-inch force main system curve and the proposed double 12-inch force main system curve.

Table 3-3. Pumping Equipment Characteristics (4 Pumps)

Manufacturer	Model	Suction ø (in.)	Discharge ø (in.)	Max Speed (rpm)	Motor Horsepower Demand (hp)	Min Flow Rate (gpm)	Runout (gpm)	Range of Efficiency (% eff)
Fairbanks Morse	**6” 5414**	**14**	**12**	**880**	**30**	**340**	**2,425**	**50-75**
Fairbanks Morse	8” 5414	14	14	880	30	700	2,650	55-79
Note: **Bolded** pump is best for alternative discussion								

Figure 3-2
Pump Replacement Option 2
Four Equal Pumps, VFD, C=120



This pumping arrangement uses three pumps to reach a firm pumping capacity of 6.5 mgd, and four pumps to reach a maximum pumping capacity of 7.0 mgd. A single pump can operate down to 350 gpm by using a variable frequency drive. Table 3-4 summarizes system performance.

Table 3-4. Pumping System Performance Characteristics (4 Pumps)

Operating Condition	Single Pump Performance	Suction Velocity (fps)	Brake Horsepower Demand (hp)
Maximum Station Capacity	1,240 gpm @ 48' TDH	2.3	21
Firm Station Capacity	1,500 gpm @ 43' TDH	2.8	22
Max. Runout (C=120)	2,450 gpm @ 22' TDH	6.9	26
Min. Flowrate @ 1.3 mgd	350 gpm @ 14' TDH	0.7	2

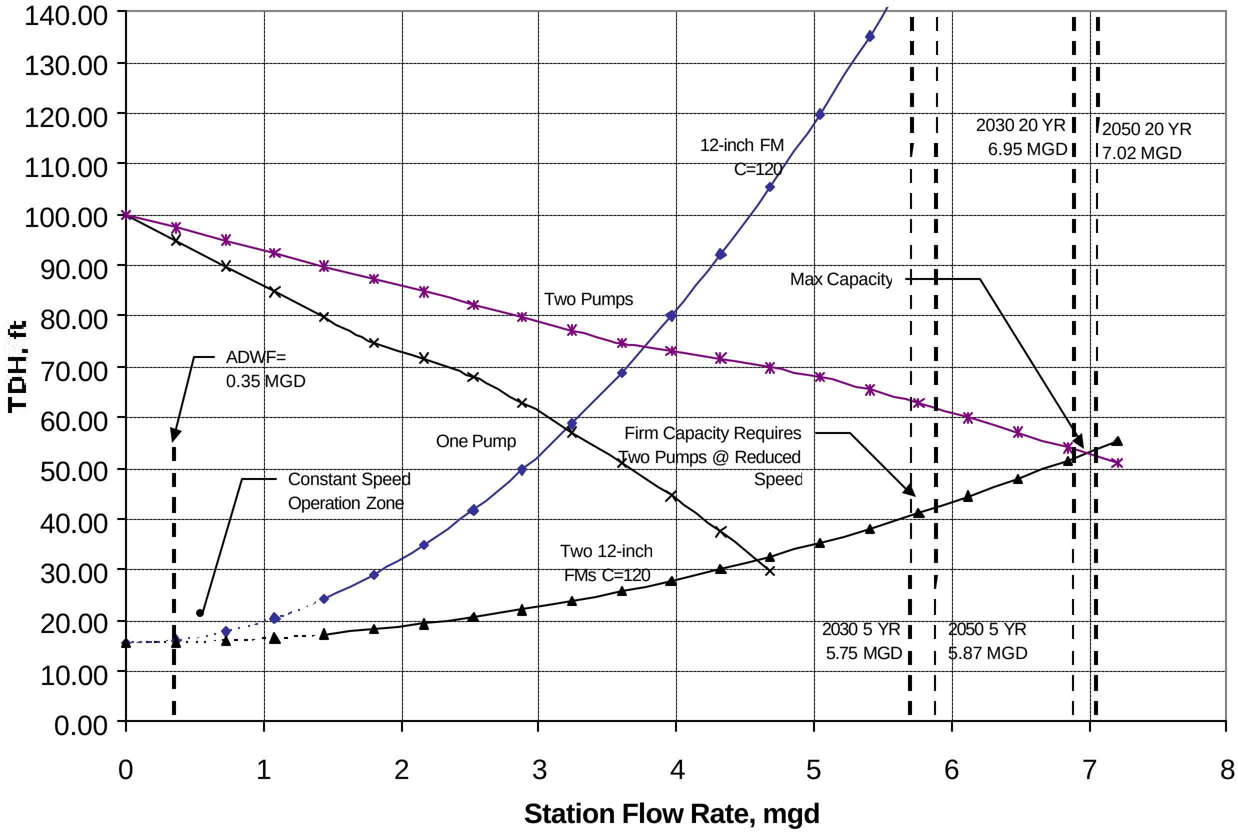
VERTICAL TURBINE SOLIDS HANDLING (VTSH) PUMPS

A system designed to use vertical turbine solids handling (VTSH) pumps was also evaluated. Table 3-5 illustrates pumps evaluated for this arrangement. These pumps can operate at variable speed over a much larger flow range than centrifugal pumps under the given range of head conditions and require less below-grade construction for installation. Operating VTSH pumps at constant speed is not particularly suited for the Pacific Pump Station, because the high pumping rate at full speed would require a large wet well volume to prevent overcycling at lower average daily flows. Figure 3-3 shows system curve relationships for a VTSH selection.

Table 3-5 Pumping Equipment Characteristics (VTSH)

Manufacturer	Model	Suction ø (in.)	Discharge ø (in.)	Max Speed (rpm)	Motor Horsepower Demand (hp)	Min Flow Rate (gpm)	Runout (gpm)	Range of Efficiency (% eff)
Fairbanks Morse	**10" VTSH**	**10**	**10**	**1770**	**40**	**900**	**4,250**	**70-85**
Fairbanks Morse	16" VTSH	16	16	1180	75	2,200	6,800	60-83
Fairbanks Morse	20" VTSH	20	20	705	75	3,000	11,600	70-86
Notes: **Bolded** pump is best for alternative discussion.								

Figure 3-3
Pump Replacement Option 3
Two Pumps VTSH, VFD, C=120



With the pump selection shown, the firm and maximum pumping capacity of the station is reached with two units in operation. A third pump would be required for mechanical redundancy to meet the firm capacity rating. A single pump can operate down to 900 gpm by using a variable frequency drive. Table 3-6 summarizes system performance.

Table 3-6. Pumping System Performance Characteristics (VTSH)

Operating Condition	Single Pump Performance	Suction Velocity (fps)	Brake Horsepower Demand (hp)
Maximum station capacity	2,430 gpm @ 48.5' TDH	NR	35
Firm station capacity	2,100 gpm @ 56' TDH	NR	35
Max. runout (C=120)	3,085 gpm @ 31' TDH	NR	31
Min. flow rate @ 1.25 mgd	900 gpm @ 76.4' TDH	NR	35

The advantage offered by VTSH pumps is a reduced volume of construction below grade. There would be no need for routine access to any space or component below grade. Depth of construction would be similar to the dry well/wet well configuration. The greatest disadvantage is that pump removal would require the motor and the entire length of pump column to be removed. The length of vertical column would be nearly 25 feet. To minimize motor noise, an enclosure might be required that could cause the entire space over the wet well to be classified for electrical design purposes. All other electrical components including the variable frequency drives would be housed in a separate, ventilated building.

SUBMERSIBLE PUMPS

A system designed around using wet pit submersible non-clog centrifugal pumps was evaluated. Table 3-7 illustrates pumps evaluated for this arrangement. These pumps can operate at variable speed but not over the full range of flows as the dry pit centrifugal pumps, which can be customized to withstand high radial thrust loads at extreme flow conditions. Submersible pumps may be more suited to a constant speed operating condition, provided that pumps can be selected for operation within their more limited range of service.

Operation beyond their best range of service can result in mechanical seal failures. More pumps or multiples of various size pumps (i.e. pumps that operate over a low flow range and pumps that operate over a high flow range) may be required to match the full range of service conditions. However, like the VTSH pumps, they require less below-grade construction for installation. Figure 3-4 shows system curve relationships for a submersible pump station.

Table 3-7 Pumping Equipment Characteristics (Submersible Pumps)

Manufacturer	Model	Suction ø (in.)	Discharge ø (in.)	Max Speed (rpm)	Motor Horsepower Demand (hp)	Min Flow Rate (gpm)	Runout (gpm)	Range of Efficiency (% eff)
Fairbanks Morse	***”5434SMV**	**10**	**8**	**1185**	**50**	**800**	**3,600**	**63-82**
Notes: **Bolded** pump is best for alternative discussion.								

Figure 3-4
Pump Replacement Option 3
Two Submersible Pumps, Constant Speed, C=120

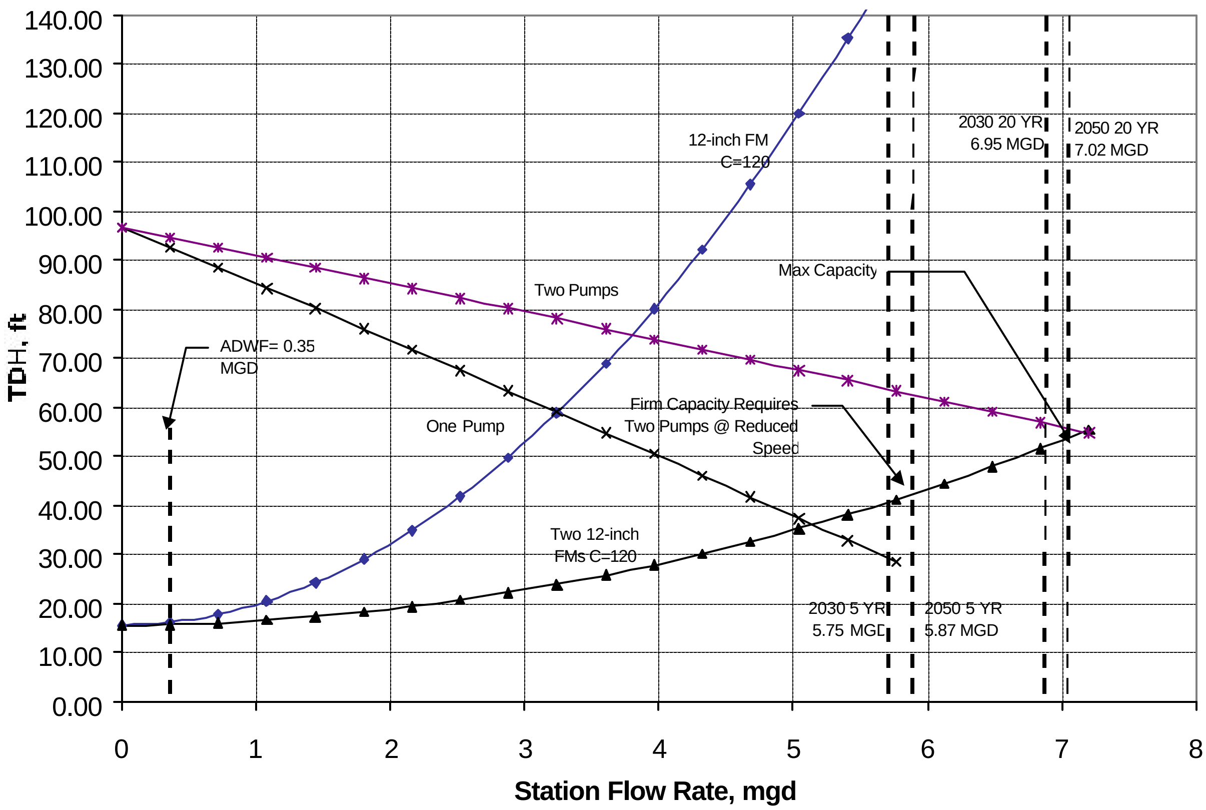


Table 3-8. Pumping System Performance Characteristics (Submersible Pumps)

Operating Condition	Single Pump Performance	Suction Velocity (fps)	Brake Horsepower Demand (hp)
Maximum station capacity	2,430 gpm @ 48.5' TDH	NR	42
Firm station capacity	2,100 gpm @ 56' TDH	NR	35
Max. runout (C=120)	3,600 gpm @ 35' TDH	NR	41
Min. flow rate @ 1.2 mgd	800 gpm @ 84.2' TDH	NR	30

CONSTANT SPEED VERSUS VARIABLE SPEED OPERATION

The pumping arrangements evaluated can be operated at either constant speed or variable speed. There are advantages and disadvantages to both options, as illustrated in Table 3-7.

The control scheme used to run the constant speed system is less complicated than that of a variable speed system. The drawbacks to a constant speed system at the Pacific Pump

Station are related to the large range of flows that should be handled by a minimum number of pumps. The average daily flow at Pacific is currently 0.35 mgd (250 gpm) and is predicted to increase only to 0.7 mgd (485 gpm). If a pump at constant speed only operates at a much larger flow rate, the wet well volume and size increase considerably over a wet well used with variable speed operation. Odorous compounds are generated at long detention times, and odors build up in the wet well air space as raw sewage reaches a septic condition.

A variable speed system at Pacific would allow a single pump to handle a wider flow capacity by changing the pump speed. The pumps selected for the evaluation in this study were evaluated for variable speed performance, based on the need to pump very low daily flows (0.35 mgd) while still having the capacity necessary to convey the firm and peak flows with a minimal number of pump units. Typically, pump control will switch from variable speed to constant speed (start/stop application) when influent flow diminishes below a certain specified rate. However, cycling frequency (wetwell volume) is not a design concern since pump motors will be started at low in-rush current through the VFD.

Table 3-9. Constant Speed versus Variable Speed Pumping

Constant Speed	
Advantages	**Disadvantages**
• A less complex and thus more reliable operating system that is easier to operate and maintain. • Drives are more energy efficient • No additional design considerations to prevent damage from harmonic resonance. • Lower equipment cost than VFD system	• Requires a larger wet well, which allows for more solids/floatables accumulation, and is more difficult and time-consuming to clean. • Longer wet well detention time may require some means of chemical addition to prevent odor and corrosion. • Transfers flows in the conveyance system in surges at a higher rate than the actual flow. • Requires more pumps to provide reasonable coverage of a wide flow range. • Pump selection can be difficult for wide flow and head calculations. • Power demand and service size could be higher based on the pump size and the higher starting current required.
Variable Speed	
Advantages	**Disadvantages**
• Small wet well with minimum retention time and lower ventilation requirements. • Smaller station substructure footprint due to smaller wet well. • Transfers flows to the conveyance system at or near actual flow rates. • Allows pumps to operate over a wider range of flows, reducing wet well detention times during low flow periods. • Power demand and service size may be less due to lower starting current required.	• Equipment for drives produce extensive radiant heat, possibly requiring station air conditioning to prevent overheating of electrical equipment. • Operation is more complex and may be less reliable. • Operating at variable frequencies requires design elements to prevent damage to equipment from harmonic resonance.

DRY WELL CENTRIFUGAL PUMPS VERSUS VERTICAL COLUMN PUMPS OR SUBMERSIBLE PUMPS

Dry well centrifugal pumps are used widely in the King County conveyance system. County O&M staff have extensive experience repairing and operating these types of pumps. The primary advantages of dry pit pumps are the ability to access the pump unit in a dry, safe environment for maintenance, interchangeability of spare parts, and proven reliability. The drawback for this system is the higher cost to provide equipment space below grade and more extensive supporting systems such as ventilation and lifting.

VTSH pumps eliminate the need for suction piping and minimize below grade construction. Only discharge piping and fittings are required for these pumps. However, in order to perform certain types of maintenance on VTSH pumps, the entire pump assembly must be removed from the wet well. This typically requires a hatch in the roof to extract the pump from the wet well by means of a boom truck. However, building height can be lower since clearance for installed lifting cranes and related equipment is not required.

Similar to the VTSH pumps, submersible pumps eliminate the need for suction piping and minimize below grade construction. Discharge piping and control valves can be housed in an adjacent below grade vault or brought to the surface and housed in a building. Because of the nature of submersible pumps, the shape of the wetwell can be either cylindrical or a more typical rectangular channel. Accessing the pumps for maintenance requires that the entire unit be extracted from the wetwell and brought to the surface. Furthermore, lock up of pump outlet and discharge piping can cause pump removal or reinstallation problems. Submersible pumps may not be suitable for variable speed operation if the range of flow varies considerably. Since submersible pumps cannot be customized to operate under extreme service conditions, service life and reliability can be reduced.

PACKAGE PUMP STATIONS

A manufactured, or package, pump station would be available as an alternative for replacing the existing package pump station. This type of station has been upgraded since the original station was built to include access stairways, equipment elevators, larger chambers, and other options. Several manufacturer's produce package stations that can be installed at the Pacific Pump Station site. Smith and Loveless package stations are available with the required capacity and were evaluated for this report.

The primary benefits of a package station are the single-vendor responsibility for providing all equipment in a working system and the shorter time for construction compared to a custom, built-in-place station. Cost savings are sought by standardizing the design and equipment, reducing overall space and using materials for construction to produce a complete "package" that can largely be lifted into place. Some of the design aspects that produce cost savings may compromise features or standards common in many other King County facilities. For example, the steel container probably will not provide a service life comparable to concrete structures and the compactness precludes future upgrading of capacity. This will require sizing for the long term which may include pumps less suited for early year, low flow conditions. Customizing any aspect of the package and its standardized equipment may be costly or limit warranties and would generally minimize the cost advantages sought by "packaging". Constant speed operation is assumed in order to avoid possible re-engineering needed to accommodate special motors or controls and possible operating range limitations. Variable speed operation could be evaluated in more detail during predesign. Other station components, such as odor control or standby power, would need to be provided in addition to the pump station package.

PIPING AND VALVES

Piping associated with the new pumping system includes pump suction and discharge piping, the header that collects flow from each pump, the existing 12-inch force main, and an additional force main. The exceptions are the submersible and VTHS pumps, which eliminate the requirement of suction piping. Station piping is sized to avoid excessively high velocities as well as low velocities on the suction lines. Isolation valves (eccentric plug valves) would be placed in pump suction and discharge piping. Spring-loaded check valves would be located horizontally in each pump discharge line. Station piping would be fabricated of welded steel pipe, sectioned with flanged or grooved-end (Victaulic) couplings to accommodate pipe assembly and installation and removal of valves. Specific surge control measures are not anticipated at this time.

WET WELL CONFIGURATION

The primary purpose of the wet well is to provide ideal hydraulic conditions for pump suction. It also provides reference water levels for pumping system control. Because raw wastewater is detained in wet wells, they can require the most disagreeable maintenance tasks. Accumulations of grease, sand and grit, and various floatables must periodically be removed. The wet well can also be a source of corrosive, hazardous, or flammable gases. Specific design features can minimize both the effort and the unpleasantness of maintenance and reduce the potential for structural deterioration and risk to personnel.

A new wet well would be configured as a trench for variable speed operation to receive the lineup of pump suction bells for the dry pit centrifugal and VTSH options. The submersible pump wet well could be constructed cylindrically, utilizing large diameter manhole sections as available, or could be a trench configuration. The dimensions would be developed to ensure good hydraulic characteristics for pump intakes and general pump operation. Sufficient depth must be provided to maintain minimum submergence of intakes, to ensure adequate net positive suction head under all operating conditions, and ideally, to ensure minimum water depth above pump volutes to preclude air binding. Above the minimum water level, depth must be provided for proper pump operation control. For variable speed operation, the operating range for the pumps would be matched to the invert and crown elevations of the influent sewer. For constant speed operation, a greater depth is required that must be balanced with horizontal dimensioning to provide sufficient operating volume. This is required to limit motor starts and prevent overheating.

Based on the pumping equipment alternatives developed earlier, wet well operating volumes and approximate sizes were calculated for constant speed operation. The volume calculated is based on the flow rates of all pumps in operation, a 50 percent overlap for each subsequent pumping unit cycle to prevent fast restarting, and a minimum 10-minute pump start cycle time at critical flow. Table 3-8 includes the wet well volume requirements for the dry well arrangements and the submersible pump option. VTSH pumps would not be considered for operation at constant speed.

Table 3-10. Wet Well Volumes and Dimensions at Constant Speed Operation

Pump Alternative	Operational Volume per cycle (gal)	Minimum Depth	Operating Volume Dimensions (feet)
Three Centrifugal Pumps (Dry Pit)	1st pump: 7,250 2nd pump: 1,800 3rd pump: 700 Total: 9,750	4.5 feet	Length: 31 Width: 7 Depth: 6
Four Centrifugal Pumps (Dry Pit)	1st pump: 6,075 2nd pump: 1,825 3rd pump: 780 4th pump: 520 Total: 9,200	4.5 feet	Length: 35 Width: 6 Depth: 6
Three Submersible Pumps	1st pump: 6,700 2nd pump: 1,550 3rd pump: 1,100 Total: 9,350	5.5 feet	Length: 35 Width: 6 Depth: 6
Notes: Operational Volume is provided above the minimum required depth			

ADDITIONAL WET WELL CONSIDERATIONS

Any wet well constructed should be equipped with water service for periodic washdown. Wet well interior surfaces should be constructed of materials resistant to corrosion or coated with corrosion-resistant materials.

Recent studies have improved upon hydraulic cleaning potential, combining pump operation with physical shaping of the wet well to assist in scouring sediment and skimming surfaces. This is achieved by forming a reversed parabolic (s-shape) entrance slope that directs influent flow energy into a hydraulic jump along the wet well floor. This design can be incorporated into a dry pit centrifugal or VTSH pump station.

PARALLEL AND REPLACEMENT FORCE MAINS

Wastewater is currently discharged from the Pacific Pump Station into a single 12-inch diameter force main, which extends approximately 2,940 feet from the pump station to the discharge point at the top of the Algona Pacific Interceptor. This force main, which was installed in 1971, is constructed of ductile iron pipe. No failures or damage to the existing force main have been reported.

The peak velocities in the existing single force main under the projected peak flows would exceed 12 fps and would require excessive horsepower to overcome pipe friction. The potential of severe hydraulic transients also increases at higher velocities. To maintain the peak velocity in the force main at 8.0 fps, a 16-inch force main or an additional 12-inch force main parallel to the existing line is required. Two 12-inch force mains would operate at about 7 fps at 7.0 mgd, which provides for a reasonable total dynamic head requirement for equipment design and capacity for future growth in the station service areas.

Two parallel force main alternatives were evaluated: a parallel 12-inch diameter force main, and a parallel 16-inch diameter force main. If the projected maximum flow of 7.0 mgd were to be split equally between the two 12-inch diameter force mains, the maximum velocity in each force main would be approximately 6.3 fps. With a parallel 16-inch force main, the system would operate on the 12-inch line for lower flows and on the 16-inch line for higher flows.

The material cost for 16-inch ductile iron pipe is approximately 50 percent more expensive per linear foot than 12-inch ductile iron pipe. Because the velocities in the force mains under either arrangement do not exceed recommended maximum velocities, the 12-inch parallel force main is the preferred alternative for increased hydraulic capacity and was therefore selected for planning purposes. Other force main arrangements, such as paralleling the ductile iron force main for the first 1,000 feet and installing a common 20-inch force main for the remaining 1,940 feet to the Algona Pacific trunk line, can be further evaluated during predesign.

INTERCEPTOR SEWER CAPACITY

The existing gravity sewers separately serve northern and southern parts of the City of Pacific collection system. The southern interceptor sewer, from manhole MH 119 to a manhole 970 feet upstream, has a capacity of 1.67 mgd. The northern interceptor sewer has a capacity of 2.15 mgd. The combined capacity of the existing interceptors is approximately 3.8 mgd, which is less than the projected maximum flow of 7 mgd. The pump station design (in particular, operating water levels in the wet well) should anticipate the replacement of these sewers to gain the higher required capacity.

Table 3-11. Interceptor Sewer Replacement

Interceptor	New Dia. (in)	Slope (ft/ft)	Q_{full} (mgd)	V_{full} (fps)

Southern interceptor	18	0.0027	3.55	3.1
Northern interceptor	18	0.0027	3.55	3.1
Influent sewer	27	0.0013	7.22	2.8

Notes:
(1) Pipe crown elevations at upstream connections would be maintained.
(2) Velocity based on Manning's n=0.013

Modifying the existing influent sewer to carry the combined flow from the interceptors to the wet well would establish the necessary water level for pump operation.

ONSITE BACKUP POWER

The existing pump station does not have onsite backup power, but rather relies on a transportable generator for emergency power. Although King County has portable generators for use at its offsite facilities, the Pacific Pump Station is located approximately 25 to 30 minutes from the East Section Reclamation Plant in Renton. Outages require personnel from Renton to transport a generator to the Pacific Pump Station. During storm events, overflows may occur due to the limited storage. The new station therefore should have onsite backup power.

Generators are sized on the brake horsepower requirements of all pumping units operating at maximum demand, plus the demand of all of the other station power requirements. Initial estimates indicate a generator size of 100 to 150 kW will be required. Detailed generator sizing will be performed during final design. An adequate fuel supply for 24 hours of generator operation would be stored onsite in underground or above ground storage tanks. A secondary primary electrical supply line from the local electrical utility as a backup source may also be evaluated during predesign.

AIR BUBBLER SYSTEM AND WET WELL FLOAT SWITCHES

The existing pumps are controlled by a bubbler system that measures the water level in the wet well. The new facility should rely on a bubbler system for wet well level monitoring, supplied from a redundant air supply system. The existing station lacks a redundant pump control system for use in the event the bubbler system fails. Float switches could be installed in the new wet well to provide a redundant means for controlling the pumps.

SCADA SYSTEM (TELEMETRY)

Metrotel telemetry would be installed at the new pump station to provide the East Section Reclamation Plant accurate real time information of the pump station operational condition. A new magnetic flow meter should be installed as a part of the next pump station upgrade. If the existing facility is kept for any significant duration, placement of a flow meter outside in a vault may be required because of spatial limitations in the existing dry well facility. At a minimum, wet well levels should be continuously recorded. A paperless recorder (as manufactured by Penny–Giles) provides adequate data at similar King County facilities.

ONSITE WATER SERVICE

Onsite water service would be provided at the new facility. C1 (potable) and C2 (nonpotable) water should be supplied for use by the Off-Site Facilities personnel during wet well washdown and other site/equipment cleaning. Water service is available at the site from a service main located in the adjacent street right-of-way. Protection of the public water supply would be required, by means of an approved backflow prevention device. The use of an air gap tank and secondary pressurization pumps would be required for protection of the in-station water system, unless there are no uses other than washdown and pump seal flushing.

HVAC

The new Pacific Pump Station should be equipped with adequate heating and cooling equipment to ensure proper operation and service conditions of equipment and instrumentation, and to provide for worker safety. The new facility may have the wet well and dry well in the same structure. If this is the case, separate ventilation systems are required for code.

ODOR AND CORROSION CONTROL

The use of odor control devices is warranted at the Pacific Pump Station, particularly during the warmer months that experience lower wastewater flows, and especially if a constant speed pump system is implemented. Smaller flows into the wet well during the warmer months of April through September would increase the wastewater retention time, and odors would be generated. The wet well must be ventilated continuously to prevent a hazardous atmosphere, maintain adequate ventilation for worker occupancy, and prevent corrosion-causing gases from damaging equipment and structures. Discharging untreated foul air into the residential neighborhood is contradictory to King County's position on odor control in its wastewater facilities.

A carbon treatment system consisting of water-regenerable carbon deep beds in FRP canisters or a removable carbon canister system such as the Calgon Carbon Corporation's Phoenix system is best suited for a facility of this size. The exact chemical composition of the wastewater and the vapor space must be measured to determine the best choice for foul air treatment. King County also uses chemical injection as a means of odor and corrosion control; however, it must be used in conjunction with a vapor treatment system.

NOISE MITIGATION

Because the Pacific Pump Station is located in a residential neighborhood, noise mitigation and controls should be incorporated into the new pump station design. Equipment that generates loud sounds, including fans, motors, starters, generators, and pumps, would be fully enclosed to maintain noise limits for residentially zoned areas. Acoustic doors and louvers would be installed as well as acoustical insulation on exterior walls where necessary.

The sound level in a dry well with the pumps in operation can exceed 90 decibels (dBA). An effective hearing protection program must be made available whenever employee exposures equal or exceed an 8-hour time-weighted average (TWA) sound level of 85 dBA[3]. In addition, feasible administrative and engineering controls must be implemented whenever employee exposures equal or exceed an 8-hour TWA sound level of 90 dBA. Although operation and maintenance personnel are not normally working in the pump station for 8-hour periods, some maintenance tasks may require personnel to be in the station for up to 8 hours. Hearing protection must be made available, and measures to reduce the sound level in the pump station should be included in the next pump station upgrade.

PUMP STATION LOCATION AND SITE REQUIREMENTS

The existing Pacific Pump Station is located within a city street right-of-way (First Avenue NW). Although First Avenue is not developed at the present time, the new pump station as proposed will present a surface structure of about 1700 square feet, which is comparable to a large residential home. A structure of this size would require the full width of right-of-way. It is assumed that this would not be acceptable to the city and property would be required for the new pump station.

Property obtained near the present site may be zoned residential, which will present more stringent development standards than commercial or industrial zoned property. Property may also be obtained along the alignment of the required additional 12-inch force main to manhole ALPAC 238. At about 1400 feet north, near Ellingson Road, commercial zoned property might be available. The area around ALPAC 238 is residential which appears to be more completely developed than the existing station location. Moving the pump station north would require extending a gravity sewer north from the present pump station site to the new site.

Figure 1-1 shows the existing pump station site and property for alternative sites near Ellingson Road and ALPAC 238. Some development has occurred at Ellingson Road since the aerial photo was taken. Exact locations can be evaluated during predesign.

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[3] OSHA Regulations: 29 CFR 1910.95. Subpart G(b).

The requirements for developing the new pump station at ALPAC 238 were evaluated for comparison with development near the existing location. The most significant difference is that a gravity sewer realignment would be required to develop a station at ALPAC 238 in lieu of the required force main. The gravity sewer would be constructed as an 18-inch to Fourth Avenue, then increase to 24-inch diameter. This increase is required to accept additional service area flows that tie into the conveyance system. Excavation depth increases from about 17 feet near the present site to about 31 feet at ALPAC 238. Excavation to these depths is substantially greater than the 4 to 5 feet of depth required for the force main. Although geotechnical explorations will be required to determine actual construction requirements, we have assumed that excavation deeper than 20 feet will require sheeting. The cost of the sheeting could make alternative construction methods such as micro-tunneling attractive if soils conditions are favorable. Micro-tunneling would reduce surface impacts as most of the street width would be required for sheeting operations. Dewatering may also become substantial at greater depths.

The depths reached at ALPAC 238 will also require the pump station to be deeper. This will increase construction costs for the structure. The increased depth is less than the pipe losses induced in the force main alternative such that total dynamic pumping head is less for a station located at ALPAC 238 although not enough to significantly change equipment requirements. The basis for cost comparison however assumes that pump station construction will be the same for any site along the force main alignment. Property cost will be site specific and has not been included in the evaluation.

The types of pumps selected will have some affect on the overall depth of the station due to submergence requirements. A pump station developed around submersible pumps will require the greatest depth of excavation.

Site upgrades should include aesthetic architectural treatments to the exterior of any above-grade structure built at the site. The design should be compatible with the surrounding neighborhood and community and should conform with current development and zoning standards. Landscaping should also be compatible with the surrounding environment.

The current site is located outside of identified floodplains (per FEMA 1995 data). However, an evaluation should be performed during predesign to determine the proper elevation for placement of electrical equipment in the new facility to protect from flooding. Other site upgrades should include facility access controls (e.g., fencing and locked gates), secured parking for offsite maintenance vehicles, and paved access to the facility. The site should be evaluated for environmental impacts or soil foundation concerns prior to final design.

CHAPTER 4 – COST EVALUATION

Planning level costs were developed based on information from recently constructed or estimated King County pump stations and standard project cost criteria. Pump station costs are presented for each type of pumping system evaluated and are based on replacement at the existing pump station site. The cost differential for constructing the pump station at two other locations is also developed. The standard project cost criteria include:

- A construction cost contingency of 20 percent.
- Sales tax of 8.6 percent of the estimated construction cost, which includes contractor mobilization and overhead and profit (12 percent).
- Allied costs of 35 percent of the total estimated capital cost.

The allied cost factor of 35 percent is included to cover King County facility management, consulting services, permitting, and insurance. Two tables are included that identify project costs. Planning-level cost estimates for new pump stations at the existing pump station site are shown in Table 4-1. Table 4-2 is included to show an alternative station siting cost comparison.

Capital costs are itemized to replace the pump station with a new facility that incorporates current industry and County standards for pump stations and is capable of handling future peak flows up to 7.0 mgd. The costs for a new parallel 12-inch force main and demolishing the existing facility are also included as part of the pump station cost. Note that the pump station costs reduce as the forcemain component is reduced for Ellingson Road sites and eventually eliminated for RE*ALPAC 238 sites. Costs for acquiring new property for the pump station sites were not factored into this evaluation.

In order to develop alternatives with sufficient accuracy, specific pumps were identified that were capable of meeting the performance criteria. For this planning level effort, only Fairbanks Morse product catalogs were consulted for centrifugal dry pit, submersible, and VTSH pumps. Smith and Loveless catalogs were consulted for the package pump station alternative. Most of the cost to upgrade the pump station is associated with 1) constructing a new pump station structure; 2) purchasing and installing new pumps and equipment, discharge piping, and force main header; and 3) installing a parallel 12-inch force main.

Without regard to site availability and property cost, the apparent cost to move the pump station north of the existing site is about $664,000 to $1,821,000.

Table 4-1. Estimated Alternative Projects Cost, Existing Pump Station Site
(1999 dollars; Seattle ENRCCI=6940)

Item	Alternative Projects Cost			
	Centrifugal Dry Pit Pump Station	VTSH Pump Station	Submersible Pump Station	Package Dry Pit Pump Station
Pump Station Facility, incl. New Parallel FM	$2,453,000	$2,149,000	$2,061,000	$2,055,000
Contractor O&P (12%)	$294,000	$258,000	$247,000	$247,000
Sales Tax, King County (8.6%)	$236,000	$207,000	$198,000	$198,000
Subtotal	**$2,983,000**	**$2,614,000**	**$2,506,000**	**$2,500,000**
Contingency at 20%	$597,000	$523,000	$501,000	$500,000
Allied Cost at 35%	$1,044,000	$915,000	$877,000	$875,000
Total Estimated Project Cost	**$4,624,000**	**$4,052,000**	**$3,884,000**	**$3,875,000**
Notes: 1. Values are rounded to nearest $1,000.				

Table 4-2. Estimated Alternative Projects Cost, Alternative Pump Station Sites
(1999 dollars; Seattle ENRCCI=6940)

Item	**Alternative Projects Cost**							
	Centrifugal Dry Pit Pump Station		VTSH Pump Station		Submersible Pump Station		Package Dry Pit Pump Station	
Location	Near Ellingson Site	Near MH ALPAC 238 Site	Near Ellingson Site	Near MH ALPAC 238 Site	Near Ellingson Site	Near MH ALPAC 238 Site	Near Ellingson Site	Near MH ALPAC 238 Site
Pump Station Facility, incl. New Parallel FM	$2,423,000	$2,303,000	$2,119,000	$1,999,000	$2,031,000	$1,911,000	$2,025,000	$1,905,000
Gravity Sewer (Open Trench Construction) [1]	$675,000	$1,900,000	$675,000	$1,900,000	$675,000	$1,900,000	$675,000	$1,900,000
Subtotal	**$3,098,000**	**$4,203,000**	**$2,794,000**	**$3,899,000**	**$2,706,000**	**$3,811,000**	**$2,700,000**	**$3,805,000**
Contractor O&P (12%)	$465,000	$504,000	$335,000	$468,000	$325,000	$457,000	$324,000	$457,000
Sales Tax, King County (8.6%)	$266,000	$361,000	$240,000	$335,000	$233,000	$328,000	$232,000	$327,000
Subtotal	**$3,829,000**	**$5,068,000**	**$3,369,000**	**$4,702,000**	**$3,264,000**	**$4,596,000**	**$3,256,000**	**$4,589,000**
Contingency at 20%	$766,000	$1,014,000	$674,000	$940,000	$653,000	$919,000	$651,000	$918,000
Allied Cost at 35%	$1,340,000	$1,774,000	$1,179,000	$1,646,000	$1,142,000	$1,609,000	$1,140,000	$1,606,000
Total Estimated Project Cost	**$5,935,000**	**$7,859,000**	**$5,222,000**	**$7,288,000**	**$5,059,000**	**$7,114,000**	**$5,047,000**	**$7,113,000**

Notes:
1. Assumes sheet piling will be removed after installation of 18-inch and 24-inch RCP sewer pipe.
2. Values are rounded to nearest $1,000.